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Mosses of Gunung Senyum Recreational Forest, a tropical limestone forest in Pahang, Peninsular Malaysia

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Abstract

Gunung Senyum Recreational Forest harbours 59 species, two subspecies and five varieties of mosses in 32 genera and 16 families that had been identified from a total of 589 specimens collected from the area. These figures represent 11.8% out of the 558 taxa, 20.2% out of the 158 genera and 34.7% out of the 46 families of mosses reported for Peninsular Malaysia. The total also represents 14.9% of the 442 taxa, 24.0% of the 133 genera and 40.0% of the 40 families of mosses recorded in Pahang. The largest family of mosses found in this limestone forest is Calymperaceae followed by Fissidentaceae. There are two new records for Pahang, *Calymperes pallidum* Mitt. and *Taxithelium binsteadii* Broth. & Dixon. The analysis of species similarities of mosses found in the study area with some other selected areas showed that Gunung Senyum Recreational Forest had a high percentage of species similarity with Perlis State Park at Wang Kelian, another limestone forest, at 38%. Corticol is the main habitat utilised by mosses in Gunung Senyum Recreational Forest with 47 taxa, followed by the lignicol and calcicol each with 35 and 26 taxa, respectively.

Keywords

Mosses, limestone hill, Gunung Senyum Recreational Forest, Peninsular Malaysia

Introduction

Forested limestone areas in Peninsular Malaysia are estimated at about 26,000 ha, mostly concentrated in the northern states and 50,000 ha in Sabah and Sarawak according to the World Wildlife Fund Malaysia (2018). More than 300 scattered limestone outcrops have been found in the Peninsular Malaysia which consist of limestone

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islands in the Langkawi archipelago, with major outcrops in Kelantan, Perlis, Kedah, Perak and northern Pahang.

Gunung Senyum Recreational Forest is one of the limestone forests in Peninsular Malaysia and is located in Jengka, Pahang (latitude 3°43.0683'N and longitude 102°26.0043'E). This recreational forest consists of several series of limestone hills, including Gunung Senyum and Gunung Jebak Puyuh. They are hills located northeast of Temerloh and north of Kampung Awah (Fontaine et al. 1988). In addition to limestone hills, this area also comprises lowland forest, especially in the area between Gunung Senyum and Gunung Jebak Puyuh. Gunung Senyum has 18 caves, while seven caves have been recorded at Gunung Jebak Puyuh. These caves originated from weathering activities where some of them are archaeological sites. Several studies in geological, human civilisation and rock life have been conducted in the areas of Jengka including Gunung Senyum and Gunung Jebak Puyuh by Jasin et al. (1995) and Fontaine et al. (1988).

The collection of plant specimens from limestone hills in Peninsular Malaysia started in August 1880 by Kunstler, a collector for Sir George King, who collected specimens in the limestone area of Gopeng, Perak. In addition, there are other collectors, namely Fox, Ridley, Kelsall and Wooldridge. As a result, about 4,500 plant specimens have been collected (Chin 1977).

The study of the limestone flora in most parts of Peninsular Malaysia was initiated by Henderson from 1923 to 1935, including Gunung Senyum and other limestone areas where about 745 plant taxa were recorded here. Also, Carr had collected plant specimens at Gunung Senyum from 1928 to 1930 but most specimens collected by him are orchids and ferns (Chin 1977). Then, Chin (1977) listed about 1216 plant taxa in a comprehensive study of limestone hills in Peninsular Malaysia consisting of pteridophytes, angiosperms and gymnosperms. He also listed Gunung Senyum as one of the largest distribution area of limestone hills in Peninsular Malaysia.

The first comprehensive study on limestone moss flora in Peninsular Malaysia was conducted by Mohamed (1987), in which about 21 limestone outcrops mainly in the northern half of the country were surveyed. He listed about 73 taxa in 40 genera and 18 families of mosses. After that, Damanhuri and Maideen (2001) recorded a total of 71 taxa in 34 genera and 18 families of mosses in Perlis State Park, Wang Kelian, Perlis. Yong et al. (2002) collected about 57 taxa in 28 genera and 13 families of mosses in Wang Mu Forest Reserve, Perlis State Park, Perlis. Later, Damanhuri et al. (2007) reported about 112 taxa in 45 genera and 19 families of mosses in Kenong Forest Park, Pahang. Lastly, Kiew et al. (2014) listed about 25 taxa in 14 genera and 11 families of mosses found in Gunung Kanthan, Perak.

Some studies in Gunung Senyum had been reported before by Chin (1977), but their collections did not cover mosses. Until now, the Gunung Senyum Recreation Forest had not been explored in terms of its moss flora. Therefore, this is the first study of moss conducted there. Also, from this study, a new record for Peninsular Malaysia has been made in this area, *Calymperes pallidum* Mitt. (Ellis et al. 2018).

Methods

This study is based on samples collected at Gunung Senyum Recreational Forest located in the Jengka Reserved Forest, Pahang (Figure 1). Collections were made along the trails in the Gunung Senyum Recreational Forest. All the specimens are curated and deposited in the Herbarium of Universiti Kebangsaan Malaysia, Bangi (UKMB).

The information regarding collection numbers, altitudes of each sample collected, date and locality of each specimen collected in Gunung Senyum Recreational Forest are shown in Table 1. Various microhabitats of mosses such as tree trunks, buttresses, rotten logs, surfaces and crevices of rocks, soil and soil banks were carefully surveyed in order to obtain as many samples and species as possible.

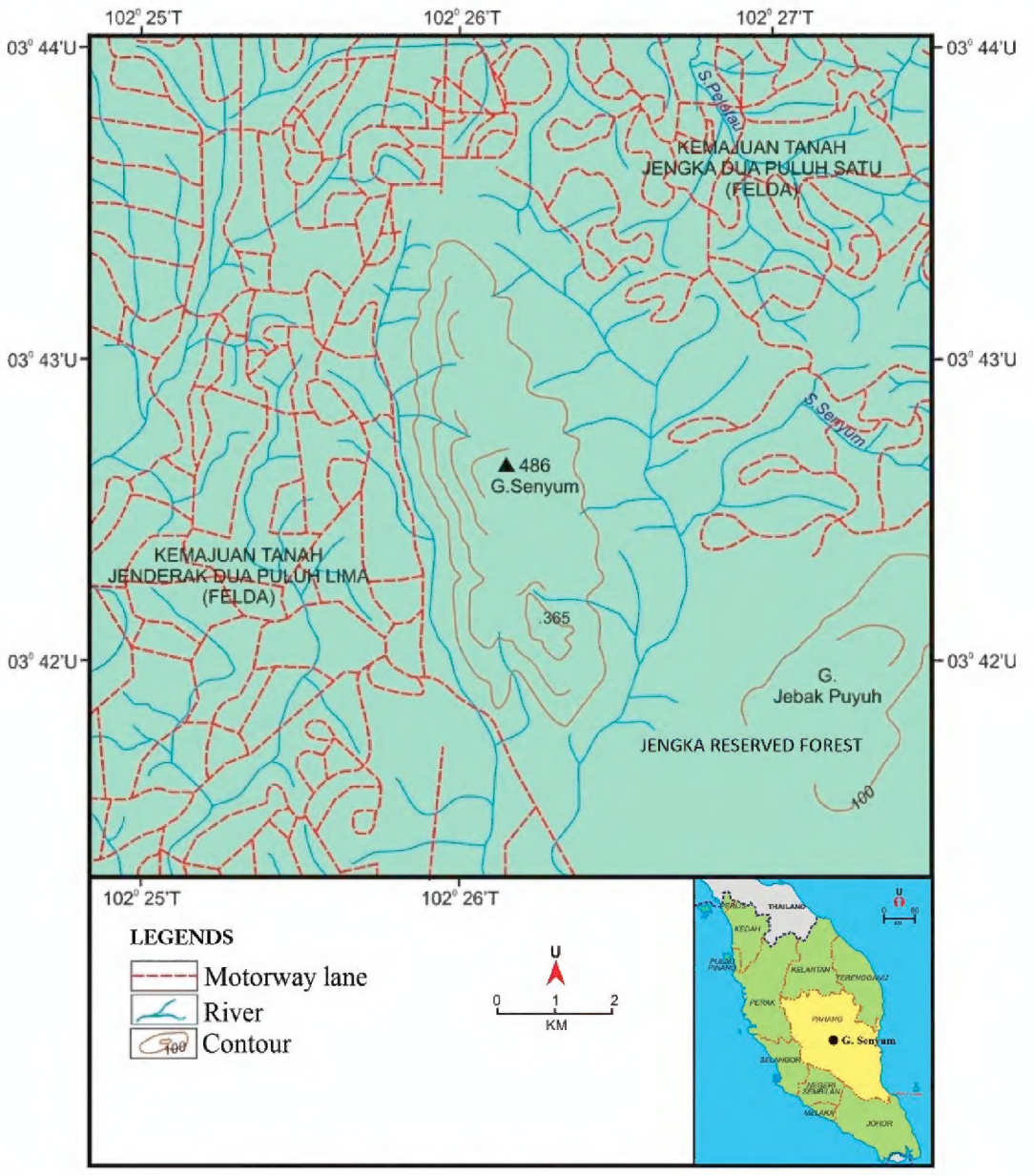

Figure 1. Map of Gunung Senyum Recreational Forest, Jengka Forest Reserve, Pahang.

Table 1. Collection information of moss specimens collected in Gunung Senyum Recereational Forest.

Date	Altitude (m)	Specimen No.	Locality
16/08/2009	85–170	1–90	The foot of Gunung Senyum
17/08/2009	75–485	91–264	Trails from the foot to the summit of Gunung Senyum
18/08/2009	95–l60	265–589	Trails to Gunung Jebak Puyuh and the surrounding areas

Results and discussion

A total of 59 species, two subspecies and five varieties of mosses in 32 genera and 16 families was found in Gunung Senyum Recreational Forest, Pahang (Table 2 and Appendix 1). These numbers represent 11.8% of the 558 taxa, 20.2% of the 158 genera and 34.7% of the 46 families of mosses reported in Peninsular Malaysia. Based on the records of mosses found in Pahang, these figures represent 14.9% of the 442 taxa, 24.0% of the 133 genera and 40.0% of the 40 families of mosses in the state. Two species are new additions to the bryoflora of Pahang namely *Calymperes pallidum* Mitt. and *Taxithelium binsteadii* Broth. & Dixon, where *C. pallidum* had been published as a new record for Peninsular Malaysia (Ellis et al. 2018). Meanwhile, a *Fissidens* species remains unidentified and requires further study to ascertain its true identity. This species will contribute to new findings for the genus in Peninsular Malaysia as for the time being there are about 28 taxa recorded in Peninsular Malaysia (Syazwana et al. 2018). The new discoveries of moss species in this area can also increase the bryoflora of Pahang in which the current record is about 442 taxa of mosses in 133 genera and 40 families. The total is higher compared to neighbour states such as Kelantan (299 taxa in 105 genera and 37 families) and Terengganu (253 taxa in 88 genera and 31 families). This shows that Pahang has the highest record of moss species compared to other states in the east coast region of Peninsular Malaysia.

Amongst the 15 families recorded, Calymperaceae has the highest number of members (20 taxa), followed by Fissidentaceae with nine taxa. Hypnaceae, Neckeraceae and Pylaisiadelphaceae are the third largest families, each represented by six taxa. This is followed by Sematophyllaceae with five taxa, Pottiaceae and Thuidiaceae with three and two taxa, respectively. The rest, Bartramiaceae, Brachytheciaceae, Bryaceae, Leucomiaceae, Meteoriaceae, Orthotrichaceae, Plagiotheciaceae and Pilotrichaceae have one taxon each (Table 2).

The largest genus found in this study is *Calymperes* with 11 taxa which belongs to the largest family (Calymperaceae) recorded here. *Fissidens* is the second largest with nine taxa. *Taxithelium* is the third largest with five taxa followed by *Vesicularia* and *Mitthyridium* with four and three taxa respectively. Genera represented by two taxa each are the *Ectropothecium*, *Leucophanes*, *Neckeropsis*, *Pelekium*, *Pinnatella*, and *Syrrhopodon*. The remainder, *Acanthorrhynchium*, *Acroporium*, *Arthrocormus*, *Barbula*, *Bryum*, *Caduciella*, *Callicostella*, *Circulifolium*, *Exostratum*, *Floribundaria*, *Hyophila*, *Isopterygium*, *Leucomium*, *Macromitrium*, *Meiothecium*, *Papillidiopsis*, *Philonotis*, *Pseudosymblepharis*, *Pseudotaxiphyllum*, *Rhynchostegium*, and *Trichosteleum* have one taxon each.

Calymperaceae is indeed a major family in lowland forest areas in Peninsular Malaysia (Damanhuri and Maideen 2001; Damanhuri et al. 2007). In this study area, Fissidentaceae, Hypnaceae, and Neckeraceae are represented by a fairly high number of taxa since the limestone rocks are largely a habitat of choice for the members of these families (Mohamed 1987).

The moss species found in Gunung Senyum Recreational Forest is compared to three other limestone forests in Peninsular Malaysia using Jaccard Coefficient of Similarity. Other limestone forest selected for comparison are Taman Rimba Kenong in Pahang (Damanhuri et al. 2007); Taman Negeri Perlis in Wang Kelian, Perlis (Damanhuri and Maideen 2001) and Gunung Kanthan in Perak (Kiew et al. 2014). Taman Rimba Kenong has the highest number of taxa, 114 taxa, followed by Taman Negeri Perlis in Wang Kelian and Gunung Senyum Recreational Forest with 72 and 66 taxa respectively. Gunung Kanthan recorded the lowest number of taxa, just 25 (Table 3).

Taman Negeri Perlis in Wang Kelian exhibited the highest degree of species similarity with Gunung Senyum Recreational Forest, which is 38.8% (Table 4). This is due to both areas consisting of limestone forests. Topographic factors also play an important role in shaping the vegetative patterns that are present in certain areas. Taman

Table 2. Summary of mosses found in Gunung Senyum Recreational Forest and its vicinity.

No.	Families	Genera	Species & infraspecific taxa
1	Bartramiaceae	1	1
2	Brachytheciaceae	1	1
3	Bryaceae	1	1
4	Calymperaceae	6	18 spp. + 2 subsp.
5	Fissidentaceae	1	8 spp. + 2 var.
6	Hypnaceae	2	6
7	Leucomiaceae	1	1
8	Meteoriaceae	1	1
9	Neckeraceae	4	6
10	Orthotrichaceae	1	1
11	Pilotrichaceae	1	1 var.
12	Plagiotheciaceae	1	1
13	Pottiaceae	3	3
14	Pylaisiadelphaceae	2	5 spp. + 1 var.
15	Sematophyllaceae	5	4 spp. + 1 var.
16	Thuidiaceae	1	2
	Total	32	59 spp., 2 subsp., 5 var.

Table 3. Summary comparing the number of moss taxa in the four areas.

Locality	Families	Genera	Taxa
Gunung Senyum	16	32	59 spp. + 2 subsp. + 5 var.
Wang Kelian	18	34	67 spp. + 1 subsp. + 3 var.
Taman Rimba Kenong	19	45	94 spp. + 4 subsp. + 16 var.
Gunung Kanthan	9	14	23 spp. + 2 var.

Table 4. Summary of the level of similarity of moss flora in selected areas.

	Gunung Senyum	Taman Rimba Kenong	Wang Kelian
Taman Rimba Kenong	33.6%		
Wang Kelian	38.8%	36.6%	
Gunung Kanthan	19.7%	15.0%	15.9%

Rimba Kenong shows the second highest similarity with Gunung Senyum Recreational Forest, which is 33.6%, meanwhile, Gunung Kanthan show the lowest degree of similarity with this forest which is 19.7%. This may be due to the fact that the number of mosses found in Gunung Kanthan is distinctly low compared to other comparable areas because the plant biodiversity in this location has been under threat from quarrying activity conducted there (Kiew et al. 2014).

The limestone habitats found in Gunung Senyum Recreational Forest can be divided into five groups based on classification by Chin (1977) and Mohamed (1987). The subdivisions are:

1. **Base of hills.** Species that live in this area include the foothills and the surrounding area. Examples are: *Acanthorrhynchium papillatum*, *Acroporium lamprophyllum*, *Calymperes afzelii*, *C. graeffeanum*, *Fissidens hollianus* and *Vesicularia reticulata*.
2. **Talus slopes.** Species that live in areas which cover the caves at the foot of Gunung Senyum, comprising piles of debris including limestone debris resulted from the weathering process of the rocks, Examples are: *Bryum coronatum*, *Caduciella mariei*, *Calymperes boulayi* and *C. erosum*.
3. **Gullies and valleys.** This area has plenty of sheltered places and can trap enough water. Examples are: *Fissidens ceylonensis*, *Macromitrium miquelii*, and *Neckeropsis lepineana*.
4. **Cliffs and near-vertical slopes.** This area provides a unique habitat for mosses because it supports very different vegetation depending on the degree of cliff gradient, presence and absence of soil and humidity levels. Examples are: *Calymperes moluccense*, *C. taitense*, *Ectropothecium dealbatum*, *Fissidens oblongifolius*, *Isopterygium pohliaecarpum* and *Pseudosymblepharis bombayensis*.
5. **Summits.** The summit of Gunung Senyum is an area composed of exposed rocks with only a small land cover. Examples are: *Floribundaria floribunda*, *Hyophila involuta*, *Isopterygium albescens* var. *albescens* and *Neckeropsis lepineana*.

Species found in this study can also be divided into four categories on the basis of their affinity to the limestone habitat (Mohamed 1987)

1. **Exclusives.** Only for species which are solely retricted to the limestone. Examples are: *Pseudosymblepharis bombayensis*, *Fissidens* cf. *hillianus* and *F. oblongifolius*.
2. **Preferents.** Occur mainly on limestone (50 to 75% of the time) but also found in non-limestone habitats. Examples are: *Barbula consanguinea*, *Bryum coronatum*, *Calymperes taitense*, *Hyophila involuta*, *Neckeropsis lepineana*, *Pelekium velatum* and *Pinnatella ambigua*.
3. **Indifferents.** Species with no particular preference for either limestone or non-limestone habitats. Examples are: *Calymperes afzelii, C. boulayi*, *C. taitense, Ectropothecium perminutum*, *Fissidens ceylonensis*, *Homaliodendron exiguum* and *Leucophanes octoblepharioides*.
4. **Casuals.** Non-limestone mosses which are collected on limestone. Example is: *Ectropothecium dealbatum*.

In this study, corticol is the most dominant way of life for mosses collected in this area with 47 taxa. Lignicol is second with 35 taxa, followed by calcicol or live on limestone with 26 taxa, then the terricol, with about 16 taxa. Rupicol and ramicol recorded the lowest number of taxa with eight and one taxa only. No moss species is found growing on leaves.

The mosses in Gunung Senyum Recreational Forest mostly live as corticol because this habitat provides adequate nutrients, water and exposure to sunlight. In contrast to the limestone rock which has few resources, the growth of mosses here is limited. The land surface is often limited to interstitials and limestone depressions. This factor makes the limestone environment vulnerable and hotter, even the absorption capacity of the soil is limited (Crowther 1987). In addition, the hot environment also accelerates decomposition of humus, thereby reducing the growth of mosses on decomposed materials.

List of mosses taxa found in Gunung Senyum Recreational Forest, Taman Rimba Kenong, Wang Kelian State Park and Gunung Kanthan

The arrangement of moss taxa are arranged alphabetically. The accepted taxa for Peninsular Malaysia follow Yong et al. (2013) except for *Pelekium bifarium* (Norhazrina et al. 2017).

Taxa	G. Senyum	T. R. Kenong	Wang Kelian	G. Kanthan
Acanthorrhynchium papillatum (Harv.) M. Fleisch.	/	/	/	–
Acroporium adspersum (Hampe) Broth.	–	/	–	–
Acroporium johannis-winkleri Broth.	–	/	–	–
Acroporium lamprophyllum Mitt.	/	–	–	–
Acroporium rufum (Reinw. & Hornsch.) M. Fleisch.	–	/	–	–
Aerobryidium aureonitens (Hook. *ex* Schwägr.) Broth.	–	/	/	–
Aerobryidium crispifolium (Broth. & Geh.) M. Fleisch.	–	/	/	–
Aerobryopsis longissima (Dozy & Molk.) M. Fleisch. var. *longissima*	–	/	–	/
Arthrocormus schimperi (Dozy & Molk.) Dozy & Molk.	/	/	/	–
Barbula consanguinea (Thwaites & Mitt.) A. Jaeger	/	–	/	–
Bryum apiculatum Schwägr.	–	/	–	/
Bryum coronatum Schwägr.	/	–	/	/
Caduciella mariei (Besch.) Enroth	/	/	/	–
Callicostella papillata (Mont.) Mitt. var. *papillata*	/	/	–	–
Callicostella papillata (Mont.) Mitt. var. *prabaktiana* (Müll. Hal.) Streimann	–	/	–	–
Calymperes aeruginosum Hampe *ex* Sande Lac.	–	/	/	–
Calymperes afzelii Sw.	/	/	/	–
Calymperes boulayi Besch.	/	–	/	/
Calymperes erosum Müll. Hal.	/	/	/	/
Calymperes graeffeanum Müll. Hal.	/	/	/	–
Calymperes lonchophyllum Schwägr. subsp. *beccarii* (Hampe) M. Menzel	/	/	–	–
Calymperes lonchophyllum Schwägr. subsp. *lonchophyllum*	/	/	/	–
Calymperes moluccense Schwägr.	/	/	/	–
Calymperes porrectum Mitt. var. *elatissimum* (M. Fleisch.) A. Eddy	–	/	–	–
Calymperes porrectum Mitt. var. *porrectum*	–	/	–	–
Calymperes robinsonii B.C. Tan & W.D. Reese	–	/	–	–
Calymperes schmidtii Broth.	–	–	/	–
Calymperes serratum A. Braun *ex* Müll. Hal.	/	/	/	–
Calymperes pallidum Mitt.	/	–	–	–

Taxa	G. Senyum	T. R. Kenong	Wang Kelian	G. Kanthan
Calymperes strictifolium (Mitt.) G. Roth	–	/	–	–
Calymperes taitense (Sull.) Mitt.	/	/	/	/
Calymperes tenerum Müll. Hal.	/	–	/	–
Chaetomitrium borneense Mitt.	–	/	–	–
Chaetomitrium orthorrhynchum (Dozy & Molk.) Bosch & Sande Lac.	–	/	–	–
Chaetomitrium papillifolium Bosch & Sande Lac.	–	/	/	–
Circulifolium exiguum (Bosch & Sande Lac.) S. Olsson, Enroth & D. Quandt	/	/	/	–
Circulifolium microdendron (Mont.) S. Olsson, Enroth & D. Quandt	–	/	/	–
Cryptogonium phyllogonioides (Sull.) Isov.	–	–	/	–
Desmotheca apiculata (Dozy & Molk.) Lindb.	–	/	–	–
Dimorphocladon borneense Mitt.	–	/	–	–
Diphyscium mucronifolium Mitt.	–	/	–	–
Ectropotheciella distichophylla (Hampe *ex* Dozy & Molk.) M. Fleisch.	–	/	–	–
Ectropothecium buitenzorgii (Bél.) Mitt.	–	/	/	–
Ectropothecium dealbatum (Reinw. & Hornsch.) A. Jaeger	/	–	–	–
Ectropothecium eleganti-pinnatum (Müll. Hal.) A. Jaeger	–	/	–	–
Ectropothecium ichnotocladum (Müll. Hal.) A. Jaeger	–	/	–	–
Ectropothecium monumentorum (Duby) A. Jaeger	–	/	–	/
Ectropothecium perminutum Broth. *ex* E.B. Bartram	/	/	/	–
Ectropothecium zollingeri (Müll. Hal.) A. Jaeger	–	–	–	/
Ephemeropsis tjibodensis K.I. Goebel	–	/	–	–
Erythrodontium julaceum (Hook. *ex* Schwägr.) Paris	–	/	–	–
Exostratum asperum (Mitt.) L.T. Ellis	–	/	–	–
Exostratum blumii (Nees *ex* Hampe) L.T. Ellis	/	/	/	–
Fissidens bogoriensis M. Fleisch.	–	–	/	–
Fissidens bryoides Hedw. var. *ramossissimus* Thér.	/	–	–	–
Fissidens ceylonensis Dozy & Molk.	/	/	/	/
Fissidens crassinervis Sande Lac. var. *crassinervis*	/	/	–	–
Fissidens crenulatus Mitt. var. *elmeri* (Broth.) Z. Iwats. & Tad. Suzuki	/	/	–	–
Fissidens crispulus Brid. var. *crispulus*	–	/	/	/
Fissidens crispulus Brid. var. *robinsonii* (Broth.) Z. Iwats. & Z.H. Li	–	/	/	–
Fissidens flaccidus Mitt.	–	–	/	–
Fissidens guangdongensis Z. Iwats. & Z.H. Li	–	/	–	–
Fissidens hollianus Dozy & Molk.	/	/	/	/
Fissidens javanicus Dozy & Molk.	–	/	/	–
Fissidens oblongifolius Hook.*f.* & Wilson	/	/	/	/
Fissidens pellucidus Hornsch.	/	/	/	–
Fissidens sp.	–	–	–	/
Fissidens sp. A	/	–	–	–
Fissidens cf. *hillianus*	/	–	–	–
Fissidens zollingeri Mont.	/	–	/	–
Floribundaria floribunda (Dozy & Molk.) M. Fleisch.	/	/	–	/
Groutiella tomentosa (Hornsch.) Wijk & Margad.	–	–	/	–
Himantocladium cyclophyllum (Müll. Hal.) M. Fleisch.	–	/	–	–
Himantocladium plumula (Nees) M. Fleisch	–	–	/	–
Hymenostylium recurvirostrum (Hedw.) Dixon	–	/	–	–
Hyophila involuta (Hook.) A. Jaeger	/	/	/	–
Hyophila javanica (Nees & Blume) Brid.	–	–	/	–
Hyophila rosea R.S. Williams	–	–	/	–
Isopterygium albescens (Hook.) A. Jaeger var. *albescens*	/	/	/	–
Leucobryum aduncum Dozy & Molk. var. *aduncum*	–	/	/	–
Leucobryum candidum (Brid. *ex* P. Beauv.) Wilson	–	/	–	–
Leucobryum javense (Brid.) Mitt.	–	/	–	–
Leucobryum sanctum (Nees *ex* Schwägr.) Hampe var. *sanctum*	–	/	–	–
Leucoloma walkeri Broth.	–	–	/	–
Leucomium strumosum (Hornsch.) Mitt.	/	–	–	–
Leucophanes angustifolium Renault & Cardot	/	/	/	–
Leucophanes candidum (Schwägr.) Lindb. var. *candidum*	–	/	–	–

Taxa	G. Senyum	T. R. Kenong	Wang Kelian	G. Kanthan
Leucophanes glaucum (Schwägr.) Mitt.	–	/	/	–
Leucophanes octoblepharioides Brid.	/	/	/	–
Macromitrium angustifolium Dozy & Molk.	–	/	/	–
Macromitrium blumei Nees *ex* Schwägr. var. *zolligeri* (Mitt. *ex* Bosch & Sande Lac.) S.L. Guo, B.C. Tan & Virtanen	–	/	–	–
Macromitrium falcatulum Müll. Hal.	–	/	/	–
Macromitrium fuscescens Schwägr.	/	/	–	–
Meiothecium microcarpum (Harv.) Mitt. var. *microcarpum*	/	–	–	–
Meteorium polytrichum Dozy & Molk.	–	/	/	–
Mitthyridium constrictum (Sull.) H. Rob.	–	/	–	–
Mitthyridium fasciculatum (Hook. & Grev.) H. Rob. subsp. *cardotii* (M. Fleisch.) B.C. Tan & L.T. Ellis	–	/	–	–
Mitthyridium fasciculatum (Hook. & Grev.) H. Rob. subsp. *fasciculatum*	–	/	–	–
Mitthyridium flavum (Müll. Hal.) H. Rob.	/	/	/	–
Mitthyridium jungquilianum (Mitt.) H. Rob.	–	/	–	–
Mitthyridium repens (Harv.) H. Rob.	/	/	–	–
Mitthyridium undulatum (Dozy & Molk.) H. Rob.	/	/	/	–
Mitthyridium wallisii (Müll. Hal.) H. Rob. var. *wallisii*	–	/	–	–
Neckeropsis andamana (Müll. Hal.) M. Fleisch.	–	–	/	–
Neckeropsis fleischeri (Dixon) A. Touw	–	/	–	–
Neckeropsis gracilenta (Bosch & Sande Lac.) M. Fleisch.	/	/	–	/
Neckeropsis lepineana (Mont.) M. Fleisch.	/	/	/	/
Octoblepharum albidum Hedw.	–	–	/	–
Oedicladium pseudorufescens (Hampe) B.C. Tan & Mohamed	–	/	/	–
Orthodontium infractum Dozy & Molk.	–	–	/	–
Papillidiopsis complanata (Dixon) W.R. Buck & B.C. Tan	/	/	–	–
Papillidiopsis malesiana W.R. Buck & B.C. Tan	–	/	–	–
Pelekium bifarium (Bosch & Sande Lac.) M. Fleisch.	/	/	/	–
Pelekium gratum (P. Beauv.) A. Touw	–	–	–	/
Pelekium velatum Mitt.	/	/	/	/
Philonotis hastata (Duby) Wijk & Marg.	/	–	–	–
Pinnatella alopecuroides (Hook.) M. Fleisch.	–	–	/	–
Pinnatella ambigua (Bosch & Sande Lac.) M. Fleisch.	/	/	/	–
Pinnatella calcutensis M. Fleisch.	–	–	/	–
Pinnatella kuehliana (Bosch & Sande Lac.) M. Fleisch.	–	/	–	/
Pinnatella mucronata (Bosch & Sande Lac.) M. Fleisch.	/	/	/	/
Pogonatum piliferum (Dozy & Molk.) Lindb.	–	/	–	–
Pseudosymblepharis bombayensis (Müll. Hal.) P. Sollman	/	/	/	/
Pseudotaxiphyllum pohliaecarpum (Sull. & Lesq.) Z. Iwats.	/	–	–	–
Rhynchostegium celebicum (Sande Lac.) A. Jaeger	–	/	–	–
Rhynchostegium javanicum (Bél.) Besch.	/	–	–	–
Stereodontopsis excavata (Broth.) Ando	–	/	–	–
Stereophyllum tavoyense (Hook.) A. Jaeger	–	–	/	–
Syrrhopodon albo–vaginatus Schwägr.	/	/	/	–
Syrrhopodon aristifolius Mitt.	–	/	–	–
Syrrhopodon confertus Sande Lac.	–	/	–	–
Syrrhopodon croceus Mitt.	–	/	–	–
Syrrhopodon involutus Schwägr.	–	/	–	–
Syrrhopodon loreus (Sande Lac.) W.D. Reese	–	/	–	–
Syrrhopodon muelleri (Dozy & Molk.) Sande Lac.	/	/	/	–
Syrrhopodon prolifer Schwägr. var. *prolifer*	–	/	–	–
Syrrhopodon spiculosus Hook. & Grev. var. *spiculosus*	–	/	/	–
Syrrhopodon trachyphyllus Mont.	–	/	–	–
Syrrhopodon tristichus Nees *ex* Schwägr.	–	/	–	–
Taxiphyllum taxirameum (Mitt.) M. Fleisch.	–	/	–	/
Taxithelium binsteadii Broth. & Dixon	/	–	–	–
Taxithelium instratum (Brid.) Broth.	/	/	/	–
Taxithelium isocladum (Bosch & Sande Lac.) Renauld & Cardot	/	/	–	–

Taxa	G. Senyum	T. R. Kenong	Wang Kelian	G. Kanthan
Taxithelium nepalense (Schwägr.) Broth.	/	–	/	/
Taxithelium kerianum (Broth.) Broth.	/	–	–	–
Thuidium plumulosum (Dozy & Molk.) Dozy & Molk.	–	/	/	–
Thuidium pristocalyx (Müll. Hal.) A. Jaeger var. *pristocalyx*	–	/	–	–
Trichosteleum boschii (Dozy & Molk.) A. Jaeger	/	–	–	–
Trichostomum brachydontium Bruch	–	–	–	/
Trismegistia lancifolia (Harv.) Broth. var. *lancifolia*	–	/	–	–
Vesicularia dubyana (Müll. Hal.) Broth.	/	–	–	–
Vesicularia miquelii (Sande Lac.) M. Fleisch.	/	/	–	–
Vesicularia montagnei (Schimp.) Broth.	/	/	–	/
Vesicularia reticulata (Dozy & Molk.) Broth.	/	/	–	–

Conclusion

Gunung Senyum Recreational Forest with its two unique and pristine limestone outcrops is suitable for exploration and study as this forested limestone area is inhabited by interesting flora and fauna. It is hoped that in future, the composition of moss flora in these limestone outcrops, Gunung Senyum and Gunung Jebak Puyuh, will be studied more deeply. Specimens from the steep cliffs in this area should be collected regularly to assess the true diversity of mosses in this unique limestone hill.

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References

Chin SC (1977) The limestone hill flora of Malaya I. Gardens' Bulletin (Singapore) 30: 165–219. https://archive.org/details/biostor-1600a56

Crowther J (1987) Ecological observations in tropical karst terrain, West Malaysia. II. Rainfall interception, litterfall and nutrient cycling. Journal of Biogeography 14(2): 145–155. https://doi.org/10.2307/2845068

Damanhuri A, Maideen H (2001) Mosses of Perlis State Park at Wang Kelian, Perlis, Peninsular Malaysia. In: Faridah-Hanum I, Osman K, Latiff A (Eds) Kepelbagaian Biologi dan Pengurusan Taman Negeri Perlis: Persekitaran Fizikal dan Biologi Wang Kelian. Jabatan Perhutanan Negeri Perlis, Kangar, 203–215.

Damanhuri A, Maideen H, Azmi A, Khamis MT, Ibrahim MN (2007) Flora Lumut Jati (Musci) di Taman Rimba Kenong. In: Muda A, Rahman AA, Hassan CH, Koh HL, Norhayati A, Latiff A (Eds) Taman Rimba Kenong, Pahang: Pengurusan, Persekitaran Fizikal dan Kepelbagaian Biologi. Jabatan Perhutanan Semenanjung Malaysia. Kuala Lumpur, 83–95.

Ellis LT, Aleffi M, Asthana G, Bhagat V, Bakalin VA, Baráth K, Becker R, Bednarek-Ochyra H, Boiko M, Brito MR, Pimentel C, Brugués M, Sáez L, Dřevojan P, Enroth J, Erzberger P, Fedosov VE, Fontinha S, Fuertes Lasala E, Gabriel R, Gallego M, Gradstein SR, Homm T, Hugonnot V, Ivchenko TG, Klimova KG, Kučera J, Lamkowski P, Lapshina ED, Lebouvier M, López González AL, Ma W-Z, Manolaki P, Monteiro J, Vieira C, Portela AP, Sim-Sim M, Maksimov AI, Norhazrina N, Syazwana N, Asyifaa S, Poponessi S, Venanzoni R, Gigante D, Prosser F, Potemkin AD, Kotkova VM, Sabovljević MS, Sabovljević AD, Schäfer-Verwimp A, Sérgio C, Garcia C, Shevock JR, Stebel A, Drobnik J, Vončina G, Wei Y-M (2018) New national and regional bryophyte records, 57. Journal of Bryology 40(4): 399–419. https://doi.org/10.1080/03736687.2018.1523601

Fontaine H, Khoo HP, Vachard D (1988) Discovery of Triassic fossils at Bukit Chuping, in Gunung Sinyum area, and at Kota Jin, Peninsular Malaysia. Journal of Southeast Asian Earth Sciences 2(3-4): 145–162. https://doi.org/10.1016/0743-9547(88)90026-8

Goffinet B, Buck WR (2018) Classification of the Bryophyta. https://bryology.uconn.edu/classification/ [accessed 18.10.2018].

Jasin B, Said U, Rosmah AR (1995) Late Middle Permian Radiolarian from the Jengka area, central Pahang, Malaysia. Journal of Southeast Asian Earth Sciences 12(1/2): 79–83. https://doi.org/10.1016/0743-9547(95)00020-8

Kiew R, Tan JPC, Saleh K, Yong KT, Kamin I (2014) An uncertain future for the plants of Gunung Kanthan, Perak, Malaysia. Cave and Karst Science 41(3): 120–128.

Mohamed MAH (1987) The limestone moss flora of Malaya. Symposia Biologica Hungarica 35: 649–663.

Norhazrina N, Patiño J, Hedenäs L, Wang J, Vanderpoorten A (2017) Taxonomic Significance of Variation in Sexual Condition in *Pelekium* and Related Genera (Thuidiaceae). Journal of Bryology 39(2): 121–127. https://doi.org/10.1080/03736687.2016.1264154

Syazwana N, Norhazrina N, Maideen H, Yong KT, Suleiman M (2018) Towards a revision of the moss genus *Fissidens* (Fissidentaceae) in Peninsular Malaysia. Malayan Nature Journal 70(3): 297–307.

World Wildlife Fund Malaysia (2018) Limestone Forests and Caves. http://www.wwf.org.my/about_wwf/what_we_do/forests_main/the_malaysian_rainforest/types_of_forests/limestone_forests_and_caves/ [accessed 20.12.2018].

Yong KT, Maideen H, Nizam MS, Damanhuri A (2002) Mosses of Wang Mu Forest Reserve, Perlis State Park. In: Latiff A, Yusoff AR, Faridah-Hanum I (Eds) Kepelbagaian Biologi dan Pengurusan Taman Negeri Perlis: Persekitaran Fizikal, Biologi dan Sosial Wang Mu. Jabatan Perhutanan Negeri Perlis, Kangar, 239-249.

Yong KT, Tan BC, Ho BC, Ho QY, Mohamed H (2013) A Revised Moss Checklist of Peninsular Malaysia and Singapore. Forest Research Institute Malaysia, Kepong.

Appendix 1. Moss checklist of Gunung Senyum Recreational Forest, Pahang

The arrangement of moss taxa follows Goffinet and Buck (2018), and families as well as the genera under each family and species under each genus are arranged alphabetically. The accepted taxa for Peninsular Malaysia follow Yong et al. (2013) except for *Pelekium bifarium* (Norhazrina et al. 2017). New additions to the bryoflora of Peninsular Malaysia and the state of Pahang are indicated by '**' and '*' respectively.

BARTRAMIACEAE

***Philonotis* Brid.**

P. hastata (Duby) Wijk & Margad. – H. Aznani & A. Damanhuri 20, 149 & 160. On exposed roots and on limestone.

BRACHYTHECIACEAE

***Rhynchostegium* Bruch & Schimp.**

R. javanicum (Bél.) Besch. – H. Aznani & A. Damanhuri 339, 347 & 422. On base of trees and on limestone.

BRYACEAE

***Bryum* Hedw.**

B. coronatum Schwägr. – H. Aznani & A. Damanhuri 24, 136, 154, 153, 157, 158, 163, 167, 168, 176, 178, 179, 188, 205, 206, 208, 210, 212, 219, 220, 221, 225, 228, 234, 236, 237, 238, 241, 243, 248, 263 & 264. On rotten logs, on soil, on tree trunks and on limestone.

CALYMPERACEAE

***Arthrocormus* Dozy & Molk.**

A. schimperi (Dozy & Molk.) Dozy & Molk. – H. Aznani & A. Damanhuri 458, 514 dan 522. On buttresses and base of trees.

***Calymperes* Sw. *ex* F. Weber**

C. afzelii Sw. – H. Aznani & A. Damanhuri 271, 278, 280, 284, 315, 326, 348, 361, 397, 398, 399, 415, 436, 477, 481 & 502. On base of trees and on buttresses.

C. boulayi Besch. – H. Aznani & A. Damanhuri 11, 12, 204, 218, 229 & 251. On limestone.

C. erosum Müll. Hal. – H. Aznani & A. Damanhuri 56a. On rotten log.

C. graeffeanum Müll. Hal. – H. Aznani & A. Damanhuri 405. On rotten log.

C. lonchophyllum subsp. *beccarii* (Hampe) M. Menzel – H. Aznani & A. Damanhuri 350. On exposed roots.

C. lonchophyllum subsp. *lonchophyllum* Schwägr. – H. Aznani & A. Damanhuri 287, 302, 311, 312, 330, 368 & 429. On exposed roots and on base of trees.

C. moluccense Schwägr. – H. Aznani & A. Damanhuri 116a. On tree trunk.

**C. pallidum* Mitt. - H. Aznani & A. Damanhuri 56a. On burnt wood.

C. serratum A. Braun *ex* Müll. Hal. – H. Aznani & A. Damanhuri 294. On rotten log.

C. taitense (Sull.) Mitt. – H. Aznani & A. Damanhuri 91, 109, 117, 123, 133, 169, 286, 346, 370, 438 & 451. On exposed roots, on limestone and on bark of liana.
C. tenerum Müll. Hal. – H. Aznani & A. Damanhuri 387. On rotten log.

***Exostratum* L.T. Ellis**

E. blumii (Nees *ex* Hampe) L.T. Ellis – H. Aznani & A. Damanhuri 324, 393, 394, 400 & 424. On rotten log.

***Leucophanes* Brid.**

L. angustifolium Renauld & Cardot – H. Aznani & A. Damanhuri 316, 337, 376, 369, 400, 457, 490 & 498. On buttresses, on base of tree and on rotten log.
L. octoblepharioides Brid. – H. Aznani & A. Damanhuri 270, 284, 323, 347, 378, 395, 404, 443, 470, 487, 495, 512, 535 & 537. On base of trees, on roots of fern, on limestone and on rotten log.

***Mitthyridium* H. Rob.**

M. flavum (Müll. Hal.) H. Rob. – H. Aznani & A. Damanhuri 274, 309, 345, 390, 410, 439, 448, 475, 499, 505, 534 & 558. On base of trees and on rotten log.
M. repens (Harv. *in* Hook.) H. Rob. – H. Aznani & A. Damanhuri 585. On tree trunk.
M. undulatum (Dozy & Molk.) H. Rob. – H. Aznani & A. Damanhuri 478. On base of tree.

***Syrrhopodon* Schwägr.**

S. albo-vaginatus Schwägr. – H. Aznani & A. Damanhuri 214, 294, 298, 314, 329, 372, 403, 507, 534, 545, 546, 578 & 579. On buttresses, on tree trunks and on rotten log.
S. muelleri (Dozy & Molk.) Sande Lac. – H. Aznani & A. Damanhuri 513 dan 526. On base of trees.

FISSIDENTACEAE

***Fissidens* Hedw.**

F. bryoides var. *ramosissimus* Thér. – H. Aznani & A. Damanhuri 396. On tree trunk.
F. ceylonensis Dozy & Molk. – H. Aznani & A. Damanhuri 1, 18, 55, 64a, 65, 80, 108, 115, 124, 125, 130, 140, 142, 143, 146, 148, 151, 152, 156, 158, 161, 166, 170, 201 & 560. On limestone, on soil, on rock in the crevice of trees and on buttress.
F. crassinervis Sande Lac. – H. Aznani & A. Damanhuri 81, 289, 442, 426, 570, 577, 580, 583 & 584. On soil, on rocks and on soil between exposed roots.
F. crenulatus var. *elmeri* (Broth.) Z. Iwats. & Tad. Suzuki – H. Aznani & A. Damanhuri 519. On exposed roots.
F. cf. *hillianus* H.A. Mill. & D.R. Sm. – H. Aznani & A. Damanhuri 35a, 88, 98, 99, 103 & 147. On limestone.
F. hollianus Dozy & Molk. – H. Aznani & A. Damanhuri 31, 48, 49, 61, 78, 93, 97, 121, 141, 126, 265, 284, 287, 290, 318, 375, 382, 383, 388, 396, 406, 414, 416, 454, 464, 491, 499, 518, 557, 571 & 575. On roots, on base and tree trunk, on rotten log and on burnt wood.
F. oblongifolius Hook.*f.* & Wilson – H. Aznani & A. Damanhuri 92, 107, 110, 112, 114, 122, 127, 131, 134, 139, 155, 180, 231 & 239. On soil, on tree trunks and on limestone.

F. pellucidus Hornsch. – H. Aznani & A. Damanhuri 425 & 510. On soil and at base of tree.

F. zollingeri Mont. – H. Aznani & A. Damanhuri 6, 9, 13a, 14, 42, 360 & 504. On rocks, on termite hill and on soil.

HYPNACEAE

***Ectropothecium* Mitt.**

E. dealbatum (Reinw. & Hornsch.) A. Jaeger – H. Aznani & A. Damanhuri 152. On limestone.

E. perminutum Broth. *ex* E.B. Bartram – H. Aznani & A. Damanhuri 8 & 56b. On rotten log.

***Vesicularia* (Müll. Hal.) Müll. Hal.**

V. dubyana (Müll. Hal.) Broth. – H. Aznani & A. Damanhuri 4, 19, 64, 295, 351, 384, 392a, 402, 431, 445, 456 & 459. On roots and base of tree, on soil and on rotten logs.

V. miquelii (Sande Lac.) M. Fleisch. – H. Aznani & A. Damanhuri 298, 444, 458 & 545. On buttresses and on rotten logs.

V. montagnei (Schimp.) Broth. – H. Aznani & A. Damanhuri 5, 44, 127, 317, 342, 366, 426, 430, 449, 461, 533 & 566. On soil, on tree trunks and on rotten logs.

V. reticulata (Dozy & Molk.) Broth. – H. Aznani & A. Damanhuri 335, 343, 362, 472, 497a & 509. On rotten log and on base of trees.

LEUCOMIACEAE

***Leucomium* Mitt.**

L. strumosum (Hornsch.) Mitt. – H. Aznani & A. Damanhuri 423. On rotten log.

METEORIACEAE

***Floribundaria* M. Fleisch.**

F. floribunda (Dozy & Molk.) M. Fleisch. – H. Aznani & A. Damanhuri 245. On bark of liana.

NECKERACEAE

***Caduciella* Enroth**

C. mariei (Besch.) Enroth – H. Aznani & A. Damanhuri 40, 353, 355, 356, 373, 418, 446, 452, 471, 473, 480, 486, 492, 520, 528a, 548 & 555. On exposed roots and on base of trees.

***Circulifolium* S. Olsson, Enroth & D. Quandt**

C. exiguum (Bosch & Sande Lac.) S. Olsson, Enroth & D. Quandt – H. Aznani & A. Damanhuri 17, 29, 36, 39, 45, 50, 72, 89, 94, 100, 102, 241, 279, 281, 291, 296, 313, 332, 352, 355a, 380, 392, 455, 462, 469, 511, 528 & 551. On limestone, on exposed roots, on soil, on rotten logs and on base of trees.

***Neckeropsis* Reichardt**

N. gracilenta (Bosch & Sande Lac.) M. Fleisch. – H. Aznani & A. Damanhuri 250, 253, 255, 258, 306, 340, 401, 440, 503, 509, 525, 529, 530, 543 & 556. On base of trees.

N. lepineana (Mont.) M. Fleisch. – H. Aznani & A. Damanhuri 116, 137, 164, 169, 177, 196, 215, 247 & 242. On limestone and on the edge of boulders.

***Pinnatella* M. Fleisch.**

P. ambigua (Bosch & Sande Lac.) M. Fleisch. – H. Aznani & A. Damanhuri 291a, 340 & 358a. On limestone and on base of trees.

P. mucronata (Bosch & Sande Lac.) M. Fleisch. – H. Aznani & A. Damanhuri 377, 402, 539, 540a & 552. On base of trees.

ORTHOTRICHACEAE

***Macromitrium* Brid.**

M. fuscescens Schwägr. – H. Aznani & A. Damanhuri 209. On rotten log.

PILOTRICHACEAE

***Callicostella* (Müll. Hal.) Mitt.**

C. papillata (Mont.) Mitt. var. *papillata* – H. Aznani & A. Damanhuri 283, 329, 393 & 566a. On rotten log, on buttresses and on tree trunks.

PLAGIOTHECIACEAE

***Pseudotaxiphyllum* Z. Iwats.**

P. pohliaecarpum (Sull. & Lesq.) Z. Iwats. – H. Aznani & A. Damanhuri 34, 67, 90 103 138, 195, 241a, 254, 324, 357, 406 & 497a (as *Isopterygium minutirameum*). On exposed roots, on soil, on limestone, on tree trunks and on rotten logs.

POTTIACEAE

***Barbula* Hedw.**

B. consanguinea (Thwaites & Mitt.) A. Jaeger – H. Aznani & A. Damanhuri 190. On limestone.

***Hyophila* Brid.**

H. involuta (Hook.) A. Jaeger – H. Aznani & A. Damanhuri 21, 41, 106, 244 & 252. On rocks, on roots of fern and on limestone.

***Pseudosymblepharis* Broth**

P. bombayensis (Müll. Hal.) P. Sollman – H. Aznani & A. Damanhuri 101, 105, 171, 118, 142, 145, 153a, 155, 159, 162, 172, 173, 174, 175, 181, 182, 183, 185, 187, 189, 193, 199, 203, 207, 211, 213, 214, 222, 224, 225, 227, 235, 240 & 249. On limestone.

PYLAISIADELPHACEAE

***Isopterygium* Mitt.**

I. albescens (Hook.) A. Jaeger var. *albescens* – H. Aznani & A. Damanhuri 8, 10, 15, 22, 35, 119, 121a, 129, 275, 292, 300, 305, 450, 506, 508, 516, 523, 527, 532 & 539. On rotten log, on soil, on exposed roots, on base of trees, on bark of lianas, on buttresses and on limestone.

***Taxithelium* Spruce *ex* Mitt.**

**T. binsteadii* Broth. & Dixon – H. Aznani & A. Damanhuri 588. On tree trunk.

T. instratum (Brid.) Broth. – H. Aznani & A. Damanhuri 126, 127, 307, 312, 320, 333, 336, 359, 391, 413, 433, 437, 439, 466, 467 & 501. On rotten logs, on soil, on exposed roots, on limestone and on bark of lianas.

T. isocladum (Bosch & Sande Lac.) Renauld & Cardot – H. Aznani & A. Damanhuri 288 & 476. On exposed roots.

T. kerianum (Broth.) Broth. – H. Aznani & A. Damanhuri 275a, 283, 309, 321, 381, 474 & 573. On base of trees.

T. nepalense (Schwägr.) Broth. – H. Aznani & A. Damanhuri 46, 53, 73, 269, 273, 299, 304, 305, 402 & 533. On rotten log, on exposed roots, on stumps of tree inside the lake and on wood.

SEMATOPHYLLACEAE

***Acanthorrhynchium* M. Fleisch.**

A. papillatum (Harv.) M. Fleisch. – H. Aznani & A. Damanhuri 444a & 458. On buttresses.

***Acroporium* Mitt.**

A. lamprophyllum Mitt. – H. Aznani & A. Damanhuri 586 & 587. On rotten logs.

***Meiothecium* Mitt.**

M. microcarpum (Harv.) Mitt. var. *microcarpum* – H. Aznani & A. Damanhuri 30, 217, 362 & 524. On limestone, on tree trunks and on rotten logs.

***Papillidiopsis* (Broth.) W.R. Buck & B.C. Tan**

P. complanata (Dixon) W.R. Buck & B.C. Tan – H. Aznani & A. Damanhuri 386, 493, 531, 549, 561, 572, 574, 582 & 586. On rotten logs, on tree trunks and branches.

***Trichosteleum* Mitt.**

T. boschii (Dozy & Molk.) A. Jaeger – H. Aznani & A. Damanhuri 303, 314a, 485, 544 & 581. On soil and rotten logs.

THUIDIACEAE

***Pelekium* Mitt.**

P. bifarium (Bosch & Sande Lac.) M. Fleisch. - H. Aznani & A. Damanhuri 3, 23, 29, 32, 38, 44, 47, 52, 55, 62, 72, 77, 87, 88, 98, 128, 300, 349 & 553 (as *Aequatoriella bifaria*). On limestone, on rotten log, on soil and tree trunks.

P. velatum Mitt. - H. Aznani & A. Damanhuri 2, 4, 5, 7, 8, 13, 19, 26, 33, 43, 51, 54, 57, 61, 63, 64, 66, 70, 71, 77, 104, 132, 269, 272, 296, 297, 301, 308, 322, 328, 325, 326, 334, 341, 344, 347a, 358, 359, 363, 364, 374, 385, 389, 391, 392, 402, 406, 407, 408, 411, 412, 417, 419, 428, 432, 435, 437, 441, 456, 463, 468, 472, 479, 480, 483, 488, 494, 500, 536, 550, 554, 559, 563, 564, 565, 567 & 569. On limestone, on rocks, on soil, on tree trunks, on rotten logs, on exposed roots and on base of trees.